GB 002054552 A
FEB 1981

12324 D/08 F01 L01 V07 P81
SIEMENS AG SIEI 27.09.77
00.00.80-GB-018567 (+743368) *(18.02.81)* G02b-05/14 *GB 2054-552
Double crucible glass fibre prod. appts. - with reciprocating rod in inner crucible for regulating glass flow through drawing nozzle

F(1-C1, 1-C7, 1-D9B, 1-E1, 4-G) L(1-F3B) 87

Glass fibre producing apparatus comprising a double crucible arrangement with at least one drawing nozzle formed by an opening in the base of the inner crucible lying within an opening in the base of the outer crucible includes a flow regulator for mechanically varying the cross sectional area of the opening in the inner crucible. The flow regulator may be an axially reciprocating rod arranged coaxially with the opening and having the same diameter as the opening.

USE

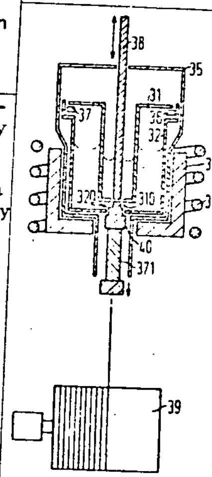
Production of optical glass fibres with a cladding of lower refracture index than the core.

ADVANTAGES

The flow regulator ensures fibres of uniform cross sectional area.

DETAILS

The apparatus comprises inner (31) and outer (32) crucibles of 90 Pt/10Rh mounted in Al_2O_3 support (33) heated by



coil (34). The drawing nozzle is formed by concentric openings (310,320) in the crucible bases, a plug (40)closing the openings during glass melting. During drawing plug (40) is removed and the cross section of the drawn fibre is controlled by a 90 Pt/10Rh rod (38) arranged coaxially in the inner crucible for axial reciprocation into or out of the inner opening (310). The fibre thickness may be continuously measured and the signal fed to a comparator which then regulates the drawing speed.(7pp464).

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(12) UK Patent Application (19) GB (11) 2 054 552 A

(21) Application No 8018567
(22) Date of filing
26 Sep 1978
Date lodged 6 Jun 1980
(30) Priority data
(31) 2743368
(32) 27 Sep 1977
(33) Fed Rep of Germany (DE)
(43) Application published
18 Feb 1981
(51) INT CL^3 G02B 5/14
(52) Domestic classification
C1M 401 PK
(56) Documents cited
None
(58) Field of search
C1M
(71) Applicant
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(54) Improvements in or relating to apparatus for the production of light-conducting glass fibres

(57) Apparatus for producing light conducting glass fibres of uniform cross-sectional area, having a core of higher refractive index and a casing of lower refractive index and at least one longitudinally-extending side coupling zone in the form of a part of the core of reduced cross-sectional area, comprises a double crucible arrangement (31, 32) having at least one drawing nozzle formed by an opening (310) in the floor of the inner crucible (31) lying within an opening (320) in the floor of the outer crucible (32) and a flow regulator for mechanically varying the cross-sectional area of the opening (310), e.g. in the form of an axially reciprocating rod (38) having the same diameter as the opening (310),

Fig. 1

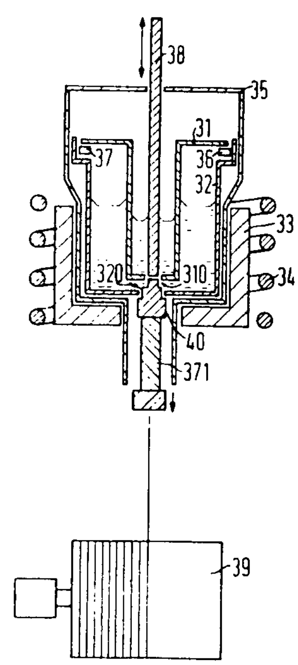

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Fig. 1

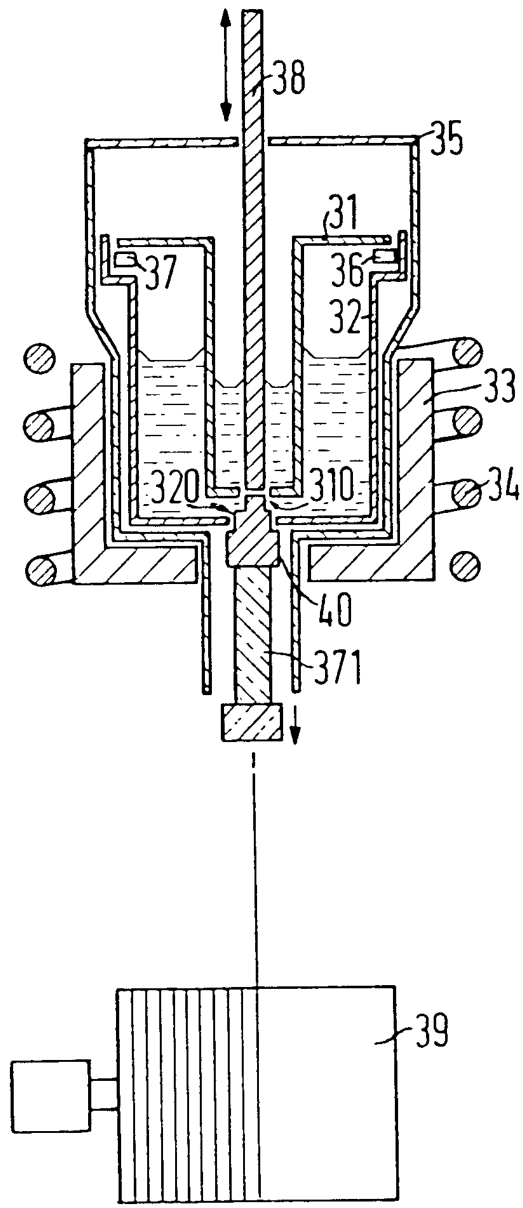

Fig. 2

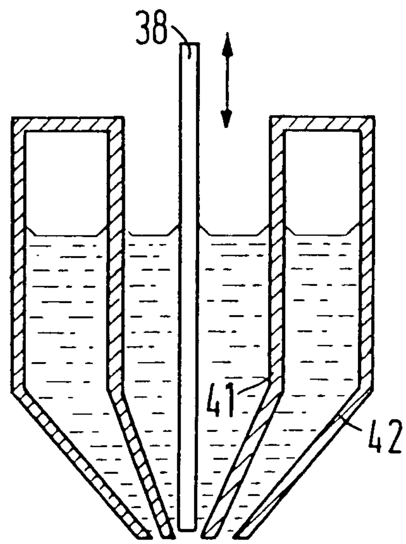

Fig. 3

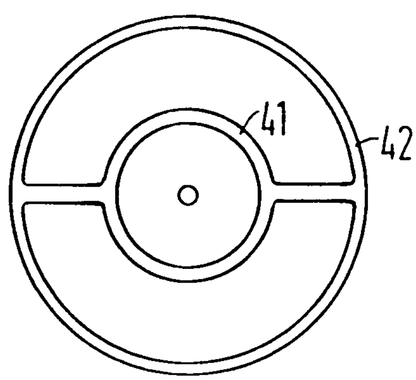

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Fig. 4

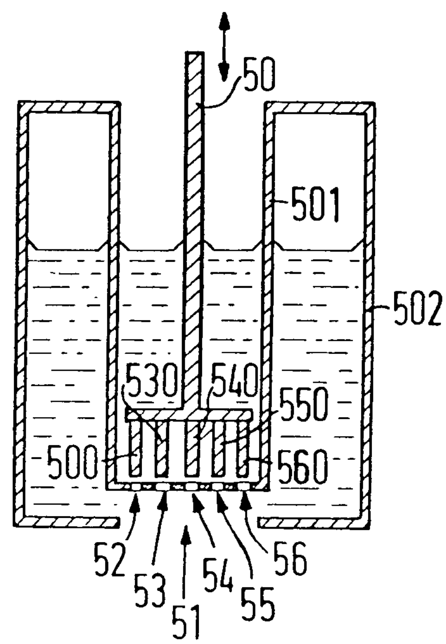
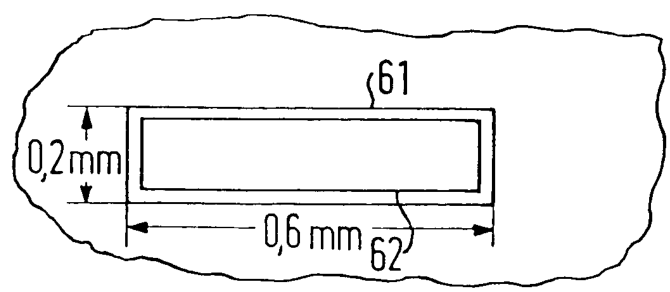


Fig. 5



SPECIFICATION

Improvements in or relating to apparatus for the production of light-conducting glass-fibres

The present invention relates to apparatus for the production of light-conducting glass fibres of substantially uniform cross-sectional area comprising a glass core of higher refractive index surrounded by a glass layer of lower refractive index which forms a casing therefor, the refractive index of the material of said fibre changing abruptly at the boundary of the core with the casing.

Glass fibres of this kind are already known (see T. Oziki and B. S. Kawasaki in Appl. Phys. Lett. 28, 1976, page 528 to 529), in which the longitudinally-extending side coupling zones are formed by local constrictions of the overall light conductor, the core diameter and the casing diameter consequently being reduced in these zones in comparison with the remainder of the fibre. Light conductors of this kind are used for optical mixers, in which the coupling zones of a plurality of such light conductors are cemented together, the light conductors being packed together as densely as possible. However, when a large number of fibres are used, it is difficult to achieve a dense packing, because the difference between the overall diameter of the fibre group in the coupling zone and outside it rapidly increases, and consequently the outer fibres of the group are subjected to a considerable bending in the coupling zone. There are, however, limits to the bending strength and resistance to pulling of an individual fibre, particularly at the constructions.

Our co-pending Application No. 38107/78 describes the use in optical mixers and distributors of glass fibres of the kind referred to above in which the fibres are of substantially uniform cross-sectional area throughout their length and in which at least one longitudinally-extending coupling zone is formed by a portion of the core of reduced cross-sectional area. It is an object of the present invention to provide apparatus for use in the production of such fibres.

According to the invention, there is provided apparatus for the production of glass fibres comprising a double crucible arrangement having at least one drawing nozzle formed by an opening in the base of the inner crucible lying within an opening in the base of the outer crucible, and a flow regulator for mechanically regulating the flow of liquid glass through the opening in said inner crucible by variation of the cross-sectional area of said opening in the inner crucible.

The flow regulator is advantageously formed by an axially movable rod arranged in the inner crucible.

In one preferred form of drawing device apparatus according to the invention, both the outer and inner crucibles of the double crucible are of funnel shape, the opening of the inner crucible being arranged in the same plane as the opening of the outer crucible.

In another advantageous form of apparatus according to the invention, the double crucible is provided with a drawing nozzle in which the opening of the outer crucible covers two or more openings of the inner crucible.

In another form of apparatus according to the invention, one or more drawing nozzles are each provided with rectangular openings.

Advantageously, the apparatus includes a fibre thickness-measuring device which is able to continously measure the thickness of the drawn fibre to provide an output signal which is fed, as an actual value, to a regulating means which serves to constantly compare the output signal with a given theoretical value, and in the event of a variation of the actual value from the theoretical value serves to regulate the drawing speed appropriately.

The apparatus used is operated in such a way that a constriction is produced in the core fibre by the flow of molten glass through the opening of the inner crucible being periodically reduced or even entirely stopped by variation of the area of the opening.

The glass fibres produced have an adequate mechanical stability in the coupling zone and, owing to their uniform thickness, a large number of such light conductors can be densely packed. Moreover, the production of such light conductors by means of the apparatus of the invention is simple and does not necessitate any appreciable additional outlay as compared with the production of conventional light conductors by the double crucible method.

The invention will now be further described with reference to the drawings, in which:–

Figure 1 is a schematic side-sectional view of one form of apparatus in accordance with the invention;

Figure 2 is a schematic side-sectional view of one form of double crucible for use in apparatus in accordance with the invention;

Figure 3 is a top plan view of the double crucible of Fig. 2;

Figure 4 is a schematic side-sectional view of another form of double crucible for use in apparatus in accordance with the invention; and

Figure 5 is a plan view on an enlarged scale of a drawing nozzle of a double crucible of rectangular cross-section, for use in apparatus according to the invention.

In the conventional double-crucible method of producing core-casing glass fibres, two crucibles are used one of which is inserted within the other and which are provided at the base with at least one drawing nozzle, such that the base of the outer crucible is provided with an opening and the base of the inner crucible

ing. The inner crucible is used for the core glass melt and the outer crucible for the casing glass melt. Before the glass melts are produced, the nozzle is sealed from below with a plug. When the glass melts have been produced in their respective crucibles, the fibre-drawing step is initiated by pulling away the plug. After subsequent passage through a coating device and a drying furnace, the drawn fibre may be wound onto a fibre-drawing drum by means of which the drawing speed can be simultaneously set.

In order to produce a glass fibre having a constricted core, in the apparatus of the invention, the double-crucible device is modified by providing the opening in the inner crucible with a flow regulator which serves to regulate the flow of the core glass melt through the opening. The constriction in the core is produced by reducing the flow of glass through the opening of the inner crucible. When the flow is cut off, it should be ensured that the flow is increased again at the correct time before the core is actually disrupted.

Fig. 1 is a side-sectional view of apparatus according to the invention. This comprises a double-crucible arrangement having an inner crucible 31 and an outer crucible 32, both made of an alloy of 90% platinum and 10% rhodium, mounted in a thermally insulating support 33 consisting for example of extremely pure Al_2O_3. The double-crucible can be heated inductively by means of a coil 34. As a protection against the ingress of impurities, the double-crucible arrangement is housed in a protective vessel 35 made of quartz glass. The inner and outer crucibles are both cylindrical and have diameters of 40 mm and 60 mm respectively and heights of 60 mm and 80 mm respectively. The inner and outer crucibles are coaxially arranged. The spacing between the bases of the inner and the outer crucibles is set by means of spacers 36 and 37 made of quartz glass and located between external flanges at the upper ends of the crucibles. Concentric openings 310 and 320 are provided in the bases of the crucibles 31 and 32 respectively, these openings together forming a drawing nozzle for the glass fibres. The openings 31 and 32 have respective diameters of 4 mm and 2mm. During the simultaneous melting of casing glass in the outer crucible 32 and core glass in the inner crucible 31, the two openings are closed by a plug 40, made, for example, of 90% platinum and 10% rhodium, in order to prevent the two types of glass from prematurely flowing out and mixing. The plug is secured, for example, by means of $Na_2O-SiO_2-Al_2O_3$ glass to a quartz rod 371. Arranged coaxially in the inner crucible is a rod 38 made, for example, of 90% platinum and 10% rhodium, which can be reciprocated axially upwards and downwards, for example, by electromagnetic means, parallel to the longitudinal axis of the crucibles. The rod has the same diameter as the opening 310 and serves as a flow regulator for core glass leaving the inner crucible. Its end adjacent to opening 310 is flat. Other designs are conceivable for the flow regulator. For example, the end of the rod adjacent the opening 310 can be pointed so that the openng and the rod co-operate in the manner of a pin-type nozzle.

When a suitable drawing temperature has been reached, the fibre-drawing process is initiated by the withdrawal of the plug 40 and the initial end of the drawn fibre is secured to a drawing drum 39; the drawing process is then continued by rotating this drum. If, during this process, the flow regulator is set to maximum flow, i.e. a rod position in which the end of the rod adjacent the opening 310 is spaced from the base of the inner crucible, a glass fibre is obtained in which the ratio of the diameters of the core and the casing is determined by the respective dimensions of the crucible openings, the drawing temperature and the distance between the bases of the inner and outer crucibles. The overall cross-sectional area of the fibre is maintained throughout the drawing process, apart from negligible variations.

If, during the drawing process, the flow regulator is set at a lower flow rate or the flow is cut off, which corresponds to a position of the rod 38 in which its end adjacent to the opening is closer to the base, so that the rod acts as a plug to at least partially close off the opening, a fibre will then be drawn which possesses a substantially uniform overall diameter, but in which, as the drawing process proceeds, the core diameter is constantly decreased until it reaches a constant core diameter which corresponds to the lower flow. When the opening 310 is entirely closed, when the remaining core glass located between the bases of the crucibles has flowed away, the core disappears completely and the glass fibre now drawn will consist only of casing-glass material. The overall cross-sectional area of the fibre drawn in this way is however substantially the same as before.

By now increasing the flow through the opening 310 it is possible to increase the diameter of the core as a result of which the cross-sectional area of the core is again increased and thus the constriction is terminated. The length and the minimum cross-section of the constrictions can be varied at will within wide limits by appropriate setting and timing of the movement of the rod 38. In the most frequent applications, the maximum possible constriction over as short a length as possible is required. In the production of such glass fibres the procedure is to completely cut off the flow through the opening 310, to wait until the desired narrowest cross-section has been reached and then to reset the original flow. The length of the constriction can be

varied by varying the drawing speed and/or the spacing between the bases of the inner and outer crucibles. In the case of large spacings, there is an increase in the length of the constriction with a uniform drawing speed beacuse of the greater residual volume of core glass trapped between the inner and outer crucibles after the closure of the opening 310. Because of this residual volume of core glass which is always present, with a given drawing speed, a given minimum cross-section and given spacing between the crucible bases, the shortest constriction length which can be achieved may be calculated from the period within which the residual volume is used up until the minimum cross-section is reached.

The effect of such a residual volume of core glass can be avoided by using a double crucible of the kind illustrated in Figs. 2 and 3. In this double crucible, the lower parts of both the outer crucible 42 and the inner crucible 41 are funnel-shaped and the opening of the inner crucible is arranged in the plane of the opening of the outer crucible.

In order to obtain fibres in which the cross-sectional area is uniform to close tolerances, it is expedient for the thickness of the drawn fibre to be continuously measured by means of a fibre thickness-measuring device arranged to produce an output signal which is fed, as an actual value, to a regulator which constantly compares the output signal with a given theoretical value and in the event of the actual value deviating from the theoretical value regulates the drawing speed to overcome the deviation.

It is also possible to produce coupling zones of any desired length and in any desired number if the flow regulator is arranged to alternate between positions corresponding to a greater and a lesser flow of core glass. After the drawing step, the fibre may be divided into portions containing the individual coupling zones from which the desired mixed elements can be produced by adhesion or fusion.

The modified double crucible illustrated in Fig. 4, in which the opening 51 in the outer crucible 502 covers a plurality of openings 52, 53, 54, 55, 56 in the inner crucible 501, can be used to produce fibres comprising a plurality of cores and thus compact, mode-selective multichannel mixers and distributor elements. The openings in the inner crucible can, for example, be arranged on a circle or on a straight line, or on any other desired line. All the openings can be closed simultaneously by plugs 520, 530, 540, 550 and 560 which are secured to a common rod 50 is a similar way to the device illustrated in Fig. 1.

In all the devices illustrated, the drawing nozzles can alternatively be rectangular. Fig. 5 is a plan view from below of a drawing nozzle of this kind, the boundary of the opening of the outer crucible being indicated at 61 and that of the opening of the inner crucible at 62. When rods are used as flow regulators, these must of course have a correspondingly rectangular cross-section.

CLAIMS

1. Apparatus for the production of glass fibres comprising a double crucible arrangement having at least one drawing nozzle formed by an opening in the base of the inner crucible lying within an opening in the base of the outer crucible, and a flow regulator for mechanically regulating the flow of liquid glass through the opening in said inner crucible by variation of the cross-sectional area of said opening in the inner crucible.

2. Apparatus as claimed in Claim 1, wherein said flow regulator is in the form of a rod arranged coaxially with the opening in the base of said inner crucible and movable in the axial direction.

3. Apparatus as claimed in Claim 1 or Claim 2, wherein at least the lower parts of said outer or inner crucibles are funnel-shaped; and wherein the opening in said inner crucible lies in the same plane as the opening in said outer crucible.

4. Apparatus as claimed in any one of the preceding Claims, wherein the opening in the base of said outer crucible covers two or more openings in the base of the inner crucible.

5. Apparatus as claimed in any one of the preceding Claims, wherein the or each said drawing nozzle has rectangular openings.

6. Apparatus as claimed in any one of the preceding Claims including a fibre thickness-measuring device when serves to continuously measure the thickness of the drawn fibre, and to provide an output signal which is fed, as an actual value, to a regulator serving to continuously compare the output signal with a given theoretical value and in the case of deviation of the actual value from the theoretical value to regulate the drawing speed to correct the deviation.

7. Apparatus for the production of glass fibres substantially as hereinbefore described with reference to and as shown in Fig. 1, or Figs. 2 and 3, or Fig. 4, or Fig. 5, of the drawings.

CLAIMS (10th Nov 1980)

1. Apparatus for the production of glass fibres comprising a double crucible arrangement having at least one drawing nozzle formed by an opening in the base of the inner crucible lying within an opening in the base of the outer crucible when viewed in the vertical direction, and a flow regulator associated with said opening in the base of the inner crucible for mechanically regulating the flow of liquid glass therethrough.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1981.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.